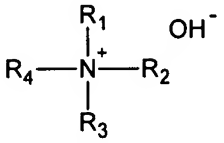
CLAIMS

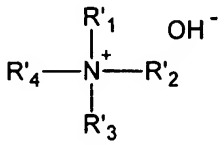
1. A catanionic membrane in the form of an organized solid bilayer comprising a lateral alternation of anionic surfactants with H^+ counterions and of cationic surfactants with cocrystallized OH^- counterions in which the mole fraction (MF): molar amount of anionic surfactants (Q_{AS})/(molar amount of anionic surfactants (Q_{AS}) + molar amount of cationic surfactants (Q_{CS})) is greater than 0.5, said membrane forming a surface that is at least locally flat, characterized in that said bilayer is stabilized with at least one polymer that is neutral and hydrophobic or of overall electrical charge opposite the effective charge of said catanionic membrane, said polymer being adsorbed onto said surface.

2. The membrane as claimed in claim 1, characterized in that the cationic and anionic surfactants are chosen from surfactants with a melting point of greater than 30°C.

3. The membrane as claimed in claim 1 or 2, characterized in that the cationic surfactants are chosen from the monocatenary and bicatenary quaternary ammoniums of formulae (I) and (I'), respectively, below:



(I)



(I')

in which:

- R_1, R_2 and R_3, which may be identical or different, represent a C_1-C_4 alkyl, C_1-C_4 hydroxyalkyl or (C_1-C_4)alkyl ether radical,
- R'_1 and R'_2, which may be identical or different, represent a C_1-C_4 alkyl, C_1-C_4 hydroxyalkyl or (C_1-C_4)alkyl ether radical,
- R'_3 and R'_4, which may be identical or different, represent a saturated or unsaturated C_8-C_{24}

hydrocarbon-based chain, a benzyl or (C_4-C_{20})alkylbenzyl radical or a (C_4-C_{20})alkyl ester group,

- R_4 represents a saturated or unsaturated C_8-C_{24} hydrocarbon-based chain, a benzyl or (C_4-C_{20})alkylbenzyl radical or a (C_4-C_{20})alkyl ester group;

and mixtures thereof.

4. The membrane as claimed in claim 3, characterized in that the C_1-C_4 alkyl radicals are methyl radicals.

5. The membrane as claimed in claim 3 or 4, characterized in that the compounds of formula (I) are chosen from cetyltrimethylammonium hydroxide, dodecyltrimethylammonium hydroxide, stearyltrimethylammonium hydroxide, tetradecyltrimethylammonium hydroxide, N-(2-carboxyethyl)-N,N-dimethyl-1-hexadecanaminium hydroxide, N-(2-hydroxyethyl)-N,N-dimethyl-1-hexadecanaminium hydroxide, cetyltriethylammonium hydroxide, dodecyltriethylammonium hydroxide, stearyltriethylammonium hydroxide, tetradecyltriethylammonium hydroxide, cetyltripropylammonium hydroxide, dodecyltripropylammonium hydroxide, stearyltripropylammonium hydroxide and tetradecyltripropylammonium hydroxide.

6. The membrane as claimed in claim 3 or 4, characterized in that the compounds of formula (I') are chosen from didodecyldimethylammonium hydroxide, didodecyldiethylammonium hydroxide, didodecyldipropylammonium hydroxide, didodecyldibutylammonium hydroxide and dicetyldimethyltrimethylammonium hydroxide.

7. The membrane as claimed in any one of the preceding claims, characterized in that the anionic surfactants are chosen from carboxylic acids with a C_8-C_{24} carbon-based hydrophobic chain with H^+ counterions and phosphates and sulfonates with H^+ counterions comprising one or two C_{12}-C_{20} alkyl chains.

8. The membrane as claimed in claim 7, characterized in that the anionic surfactants are chosen from myristic acid, lauric acid and palmitic

acid, phosphates, sulfates, benzyl sulfates and monocatenary glycerol monoesters.

9. The membrane as claimed in any one of claims 3 to 8, characterized in that the bilayers consist:

a) either of a cationic surfactant of formula (I) as defined in claim 3 and in which the radicals R_1, R_2 and R_3 are identical and represent a methyl radical and R_4 represents a hydrocarbon-based chain containing X carbon atoms, X being between 8 and 24 inclusive, combined with a carboxylic acid as defined in claim 6 in which the C_8-C_{24} carbon-based hydrophobic chain contains X ± 4 carbon atoms;

b) or of a cationic surfactant of formula (I') as defined in claim 3 in which the radicals R'_1 and R'_2 are identical and represent a methyl radical and R'_3 and R'_4 are identical and represent a hydrocarbon-based chain containing X carbon atoms, X being between 8 and 24 inclusive, combined with a carboxylic acid as defined in claim 6 in which the C_8-C_{24} carbon-based hydrophobic chain contains X ± 4 carbon atoms;

c) or a phosphate or a sulfonate comprising two identical alkyl chains containing X carbon atoms, X being between 8 and 24 inclusive, combined with a cationic surfactant of formula (I) as defined in claim 3 and in which the radicals R_1, R_2 and R_3 are identical and represent a methyl radical and R_4 represents a C_8-C_{24} alkyl chain;

d) or a phosphate or a sulfonate comprising only one alkyl chain containing X carbon atoms, X being between 8 and 24 inclusive, combined with a cationic surfactant of formula (I') as defined in claim 3 and in which the radicals R'_1 and R'_2 are identical and represent a methyl radical and R'_3 and R'_4 are identical and represent a C_8-C_{24} alkyl chain.

10. The membrane as claimed in claim 9, characterized in that the bilayers are formed from a combination of cetyltrimethylammonium with OH^-

counterions and myristic acid with H^+ counterions.

11. The membrane as claimed in any one of the preceding claims, characterized in that the mole fraction $Q_{AS}/(Q_{AS} + Q_{CS})$ is between 0.52 and 0.66.

12. The membrane as claimed in any one of the preceding claims, characterized in that the bilayers also contain a minor molar amount of anionic surfactants with metal counterions.

13. The membrane as claimed in any one of the preceding claims, characterized in that the neutral polymers are nonlipid polymers chosen from polysaccharides, polyethylene glycols, polyoxyethylenes, polyvinylpyrrolidone, polyvinyl alcohols, oxyethylenated diblock polymers, block copolymers based on ethylene oxide and propylene oxide, and triblock copolymers composed of hydrophilic-hydrophobic-hydrophilic blocks.

14. The membrane as claimed in any one of claims 1 to 12, characterized in that the polymers with an overall electrical charge opposite the effective charge of the catanionic membranes are polymers of weakly negative electrical charge chosen from polyacrylates, polymethacrylates, polyethyl methacrylates, polybutyl methacrylates and polystyrenesulfonates, said polymers being substituted to more than 75% randomly with neutral water-soluble groups.

15. The membrane as claimed in claim 14, characterized in that said polymer is a polyethylene glycol with a molecular mass of between 5000 and 50 000 Da.

16. The membrane as claimed in any one of the preceding claims, characterized in that said polymers represent from 10% to 400% by weight relative to the total weight of the bilayer.

17. The membrane as claimed in any one of the preceding claims, characterized in that its mole fraction $Q_{AS}/(Q_{AS} + Q_{CS})$ is between 0.55 and 0.58 and in that it is in the form of faceted hollow microcrystals.

18. The membrane as claimed in claim 17,

characterized in that it is in the form of hollow polyhedra comprising from 12 to 30 approximately triangular faces.

19. The membrane as claimed in claim 18, characterized in that it is in the form of hollow icosahedra with an inner volume of between 0.1 and 10 μ^3.

20. The membrane as claimed in claim 18 or 19, characterized in that, within the organized solid bilayer of each of the faces of said microcrystals, the lateral alternation of the cocrystallized anionic and cationic surfactants is hexagonal, the flat part of said faces consisting solely of species containing H^+ or OH^- counterions in stoichiometric amounts, whereas the apices of said faces are in the form of an internal semitorus predominantly formed from the anionic species in excess and in an amount sufficient to obtain an MF $Q_{AS}/(Q_{AS} + Q_{CS})$ of between 0.55 and 0.58.

21. The membrane as claimed in claim 20, characterized in that the apex of each of the faces of a microcrystal forms a pore, together with the apices of the adjacent faces of the same microcrystal.

22. The membrane as claimed in claim 17, characterized in that it is in the form of fragments of hollow polyhedra constituting a stack of three-dimensional catanionic crystals in the form of a "pile of plates".

23. A process for preparing a catanionic membrane as defined in any one of claims 1 to 22, said process being characterized in that it comprises the following steps:

1) a first step of formation of unilamellar vesicles by mixing, in an aqueous solvent of low conductivity:

a) a cationic surfactant (CS) with OH^- counterions in a molar amount Q_{CS} and

b) one or more anionic surfactants (AS) in a molar amount Q_{AS} strictly greater than Q_{CS}, and corresponding to equations (1)

to (3) below:

$$Q_{AS} = Q_{AS1} + Q_{AS2} \quad (1)$$

$$Q_{AS1} = Q_{CS} \quad (2) \text{ and}$$

$$Q_{AS2} < 2(Q_{CS}) \quad (3)$$

in which:

- Q_{AS1} is the molar amount of an anionic surfactant with H^+ counterions
- Q_{AS2} is the molar amount of an anionic surfactant with H^+ counterions or with metal counterions, said surfactants having a carbon-based chain identical to that of the CS or of the AS with H^+ counterions used in an amount Q_{AS1},

said mixture of cationic surfactant and of anionic surfactant being prepared at a temperature above the melting point of the chains of said surfactants;

2) a second step of obtaining flat aggregates formed from only one interdigitated or noninterdigitated crystalline molecular bilayer, by cooling the mixture obtained in the first step to a temperature below the melting point of the chains of the surfactants present in the mixture;

3) a third step of stabilizing the crystalline molecular bilayers obtained above in the second step, by adding at least one neutral and hydrophobic polymer or a polymer of weakly negative overall electrical charge dissolved in an aqueous solvent of low conductivity, said step being performed at a temperature below the melting point of the chains of the surfactants present in the mixture.

24. The process as claimed in claim 23, characterized in that, when the excess of anionic surfactant consists of anionic surfactants with metal counterions, then the first step of the process comprises:

- a first substep in which the cationic surfactant with OH^- counterions is first mixed with the anionic surfactant with H^+ counterions in an amount Q_{AS1}

equal to Q_{CS}, and then

- a second substep in which the molar amount Q_{AS2} of anionic surfactant with metal counterions is then added.

25. The process as claimed in claim 23 or 24, characterized in that the aqueous solvents have a conductivity of less than or equal to 1 MOhm.

26. The process as claimed in any one of claims 23 to 25, characterized in that the aqueous solvents are chosen from water and glycerol, and mixtures thereof.

27. The process as claimed in any one of claims 23 to 26, characterized in that, during the first step, the total concentration of surfactants in the solution is between 0.01% and 3% by weight relative to the total weight of said solution.

28. The process as claimed in any one of claims 23 to 27, characterized in that, during the first step, the mixture is heated to a temperature of greater than 30°C and less than 80°C.

29. The process as claimed in any one of claims 23 to 28, characterized in that, during the first step, at least one active substance is added to the mixture.

30. The process as claimed in claim 29, characterized in that the active substance is chosen from pharmaceutical active principles, active substances for cosmetic purposes, cells and DNA or RNA fragments.

31. The process as claimed in any one of claims 23 to 30, characterized in that the volume fraction of polymer added to the mixture during the third step is between one and two times the total mass of the cationic and anionic surfactants.

32. A catanionic membrane as defined in any one of claims 1 to 22, for use as medicament for the vectorization of active species or for the retention by adsorption and slow diffusion of volatile molecules.

33. The catanionic membrane as claimed in

claim 32, characterized in that it is in the form of a faceted hollow polyhedron and is used for:

- encapsulating medicaments, for the purpose of vectorizing them,
- encapsulating whole bacteria or DNA or RNA fragments,
- retaining reagents for chemical reactions taking place inside the polyhedra,
- performing precipitation or crystallization reactions inside the polyhedra, by slow diffusion of reagents inside across the pores of the polyhedra,
- as cosmetic ingredient for the manufacture of creams, obtained by flocculation in the form of bunches of polyhedra, and allowing the efficient diffusion of active molecules after adsorption of the polyhedron onto surfaces of opposite surface electrical potential.